AN OLD EROSION SURFACE IN IDAHO: ITS AGE AND VALUE AS A DATUM PLANE[1]

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THE EROSION SURFACE

Evidences of a former erosion cycle.—A plateau surface has long been recognized in Idaho, and over much of the state it has been described as a feature of erosion. The observations of the writer have been confined to an area of about 5,000 square miles in the eastern part of that great highland mass known as the Salmon River Mountains, but the literature shows that a description of this area is applicable to much of the state.

The Salmon River Mountains are characterized by deep canyons separated by even-crested divides, which here and there widen out into broad flats. Within the region there is not only a striking accordance of summit levels; there is a general continuity of level summit areas. Plateau remnants several square miles in extent are not uncommon. One of these is Poverty Flat near Challis in Custer County. It is a comparatively level tract of about 25 square miles, and occurs at an elevation 9,600 feet above sea (Fig. 1). Bordering it are narrow valleys as much as 5,000 feet deep, but beyond them high, even-crested ridges and occasionally flat areas continue to the horizon in every direction. The rocks forming this flat are steeply tilted schists, slates, and quartzites, the latter

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here and there forming low hills. Near Leesburg, in Lemhi County the plateau surface is also well preserved. Here it is about 8,500 feet in elevation, and breaks off abruptly along the canyon of Salmon River, which flows in a gorge 5,500 feet deep.

Equally significant with the high flat-topped areas are the innumerable level-crested divides which extend out from them, and with other more isolated summits form a veritable labyrinth of highland tracts. Also worthy of note, as indicating that streams once flowed near the summit levels, are occasional rock-cut terraces which parallel the plateau surface but at slightly lower

FIG. 1.—A portion of Poverty Flat, which has an elevation of 9,600 feet, and is bordered by canyons as much as 5,000 feet deep. The spur on the right shows the highly inclined beds across which the flat is developed.

levels. One of these occurs along the west side of Spring Mountain, and another along the south side of Poverty Flat.

These several features clearly indicate a plateau surface, now deeply dissected, and when it is remembered that it is cut across highly inclined rocks of diverse composition, it seems equally clear that it could only have been developed by profound erosion. The region was reduced to gentle relief, and later raised to its present elevation.

Correlation and extent.—Mr. Lindgren describes the same surface in west-central Idaho, and concludes that[1] "The whole mountain region should probably be regarded as a vast plateau. . . . . The uplift of this plateau and its intricate and deeply cut drainage system evidently antedate the Miocene period." These high-

[1] Waldemar Lindgren, *Twentieth Annual Rept., U.S. Geol. Surv.*, Pt. III (1900), 77.

lands extend to the north, and in speaking of them the same writer says:[1] "Their combined crest-line would form an undulating plain differing little in elevation in the various parts of the Clearwater Mountains. From their westerly margins the mountains slope rapidly to the lava plateau, which has an elevation of 3,000 to 3,500 feet. . . . . Along Salmon River the high mountain plateau extends farther westward, and its last ramparts overlook the great bend of that river, rising 6,500 feet above its water line." Mr. Lindgren's conclusion is that "We must regard this surface as the result of erosion. The country was worn down to a comparatively gentle topographic feature, then uplifted and deeply dissected by canyons."

Mr. Calkins[2] describes the Coeur d'Alene Range, still farther north, as having a "general aspect similar to that of a maturely dissected plateau." He describes also the Cabinet and Purcell ranges in western Montana, in similar terms. East of these, Mr. Willis[3] recognized a peneplain over the Galton Range, and suggests that it may continue eastward over the Livingston and Lewis ranges. Northward in British Columbia the Interior Plateau is described by G. M. Dawson[4] as an elevated peneplain of Eocene age. South of this the writer[5] recognized what was thought to be the same surface at Republic, Washington.

The extent of the old erosioned surface can only be outlined in a general way because of the many localities where its identity has been destroyed and the broad areas which have not been studied physiographically. The above citations show, however, that a plateau surface cut across greatly disturbed beds extends over much of Idaho and into adjoining parts of Montana, Washington, and British Columbia. The areas in Idaho are continuous; those elsewhere are more isolated, but that all date from the same cycle of erosion will appear rather obvious during the later discussion.

Elevation and preservation.—The combined crest lines of the plateau areas in Idaho would form an undulating plain which

[1] Waldemar Lindgren, *P. P. 27, U.S. Geol. Surv.* (1904), 14.

[2] F. C. Calkins, and D. F. MacDonald, *Bull.* 384, *U.S. Geol. Surv.* (1909), 14, 19.

[3] Bailey Willis, *Geol. Soc. Amer.*, XII (1901), 349.

[4] G. M. Dawson, *Trans. Royal Soc. Canada* (1890), 13.

[5] J. B. Umpleby, *Wash. Geol. Survey, Bull. I* (1910), 11.

reaches its maximum elevation of about 10,000 feet along a course through Gilmore and Challis. Northwestward it grades off to 8,500 feet in the north part of Lemhi County, and thence to about 7,000 feet in the Clearwater Mountains. This elevation is also common in northwest Montana, but westward in the Colville Mountains and on north in the Interior Plateau the summits are about 5,000 feet above sea.

Faulting and folding have affected the plateau area of central and eastern Idaho since its last elevation, but through all, the integrity of the old surface has persisted in a remarkable degree. Local prominences above the general level, though not characteristic of the region, occur. Some of these are undoubtedly erosion remnants, but others probably involve faulting, and some may be due to folding. In western Montana the old surface appears from the literature to be far less perfectly preserved. In northeastern Washington and in British Columbia it is also preserved imperfectly. Here there is a remarkable accordance of summit levels, but no large plateau remnants, such as those in Idaho, have been described.

Age of the Surface

Evidence from the area.—After the last general elevation of the region great valleys were developed, and in these extensive lake beds accumulated during the Miocene period. Such deposits occur at Salmon, Idaho,[1] in western Montana,[2] at Republic, Washington,[3] and at various places in the Interior Plateau of British Columbia.[4]

Allowing the Oligocene for the development of the broad valleys occupied by the Miocene lake beds, the old erosion surface is pre-Oligocene. On the other hand, it cuts all the older formations of the region including the granite, which is post-Triassic. Thus from evidence within the plateau region the old erosion surface is pre-Oligocene and post-Triassic.

[1] J. B. Umpleby, *Bull. U.S. Geol. Surv.* (now in manuscript).

[2] Earl Douglass, *Mont. Univ. Missoula, Mont.*, 27 pp., 4 plates, 1899; *Carnegie Mus. Annals*, V (1909), 159-65.

[3] J. B. Umpleby, *Bull. I, Wash. Geol. Surv.* (1910), 11.

[4] G. M. Dawson, *Trans. Royal Soc. Canada* (1890), 14.

Evidence from nearby areas.—It is thought that adjoining regions afford further evidence as to the age of this surface. Extensive deposition is a corollary of profound erosion, hence we should expect to find a sedimentary record of the cycle of erosion represented by the present plateau surface. The Rocky Mountain

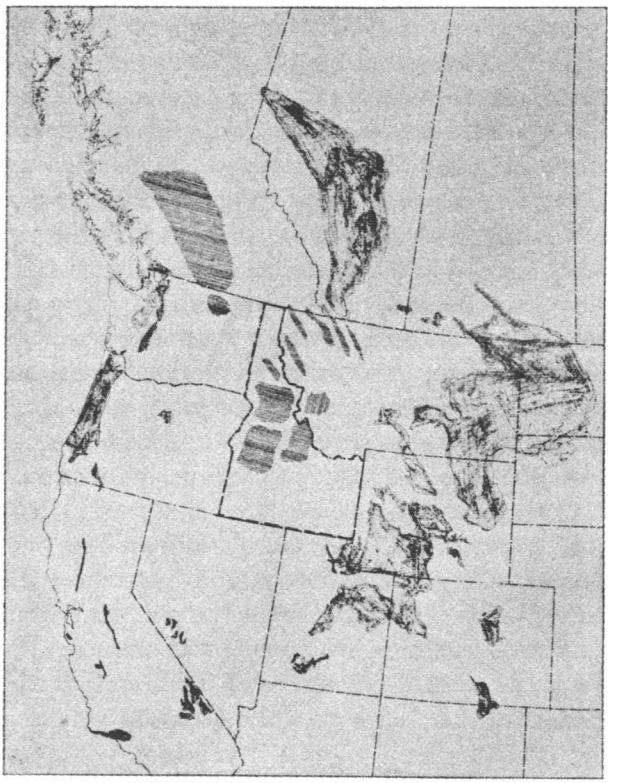

FIG. 2.—The figure illustrates the distribution of Eocene sediments in the Northwest. The horizontal lines indicate areas which have been described as of the plateau type. The area of vertical lines is similar but is based on oral communications. Adapted from the Geologic Map of North America, with the plateau areas added.

region is known to have supplied vast volumes of sediments during the Cretaceous, but not until the Eocene does the distribution of sediments bear a significant relation to the present plateau area. Fig. 2 illustrates the distribution of the Eocene sediments in the

Northwest and the parallel lines of the same figures show the position of the areas described as representing the plateau type. The distribution of Eocene sediments around these areas strongly suggests a relation between the two. It seems that the sediments could not have been derived from the region after its last elevation for two reasons: (1) It is very doubtful if the plateau is sufficiently dissected to afford the volume of material represented by the Eocene beds, and (2) All the more important valleys of the area drain westward, and in all probability have done so throughout their entire history. This is true of the Rocky Mountain trough, the Purcell trough, and the Snake, Salmon, and Columbia river channels. These, together with their tributaries, represent perhaps 90 per cent of the present dissection of the plateau region. If we assume that the old erosion surface is pre-Eocene the material derived from these several valleys may be thought to account for the narrow fringe of Eocene sediments on the west, but cannot account for the incomparably more extensive Eocene beds which lie to the east of the present plateau region.

Conclusion.—From this line of evidence it is concluded that the Eocene sediments were derived from the plateau area during that great cycle of erosion which resulted in a comparatively level surface, and therefore that the plateau region of the present day was characterized by gentle topographic features at about the close of the Eocene period. Whether or not that former great cycle of erosion began with the Eocene may be an open question, but that it closed with the Eocene, and therefore that the present plateau surface is of Eocene age, there seems to be little room for doubt.

The Eocene Surface as a Datum Plane

Over much of Idaho no satisfactory datum plane has been recognized between the Algonkian and the Pleistocene. In the southeastern part of the State formations of Paleozoic age are present and along the western side are the great sheets of Miocene basalt. Other datum planes are recognized, but they are all well removed from the plateau area. Thus where a datum plane is most needed the Eocene erosion surface is best preserved.

The value of this surface in time determinations is perhaps greatest in dating the ore deposits of the plateau region. Two distinct periods of mineralization are recognized in this area. The earlier deposits are cut by the Eocene surface, but the later are inclosed in or associated with eruptive rocks which fill valleys developed after its elevation. Thus the Eocene surface was developed during the interval between two great periods of mineralization. Reasoning from it as a datum plane the deposits may be rather definitely placed in time. On the one hand is the Pleistocene glaciation and the amount of erosion which preceded it but followed the veins, thus placing a fairly definite limit. On the other the granite, which is older than the earlier veins, is assigned to the latest Cretaceous or earliest Eocene as brought out in the next section.

Age of Granitic Intrusions Suggested by the Eocene Surface

There are many granitic batholiths within the plateau region. The largest of these is the one in central Idaho, which is more than 20,000 square miles in extent. Several others approach to or exceed 1,000 square miles in area, and those of smaller size are to be numbered by the score. Indeed, probably one-third of the surface rock throughout the present plateau region is granite or closely allied batholithic types. Both broadly and locally these intrusions vary from normal granite through soda granite and quartz-monzonite to quartz-diorite. Their distribution is shown by Fig. 3. A comparison of this with Fig. 2 brings out the striking accordance in distribution between the area of granitic intrusions and the plateau. Their coextent suggests a genetic relation between them, but the granite constitutes a larger part of the plateau surface; hence, if a relation exists it must date from the earlier part of the erosion cycle during which the Eocene surface was developed. The problem, therefore, is to show whether the granite entered at this or at a still earlier time. Probably most geologists will agree in the opinion that such a tremendous volume of magmatic material did not enter beneath the region without causing or accompanying a profound elevation of the

surface; yet the area of granitic intrusions does not show a significant relation to surrounding sedimentary deposits until the Eocene. It is believed, therefore, that the granite intrusions accompanied the elevation which initiated that great cycle of erosion which

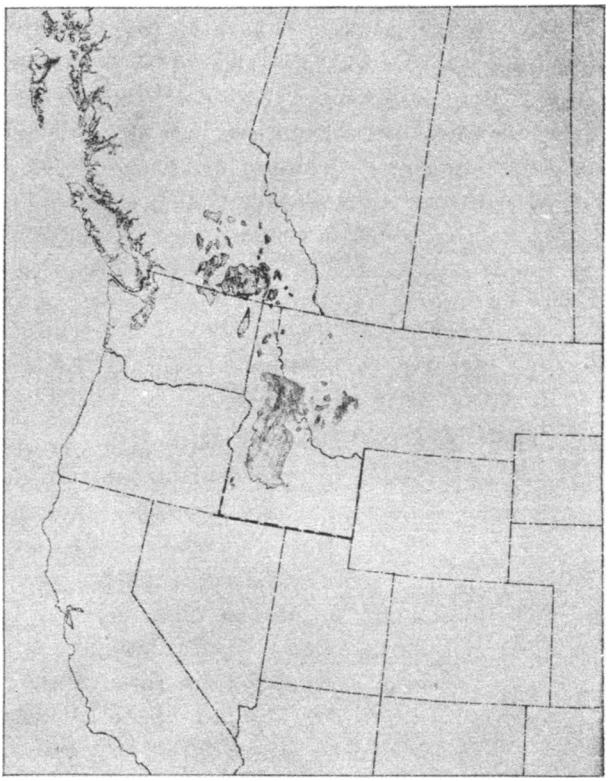

FIG. 3.—The figure shows the distribution of granitic rocks in the plateau region. Adapted from the Geologic Map of North America.

resulted in the Eocene surface. The granite batholiths of the plateau region therefore are assigned to the late Cretaceous or early Eocene.[1]

[1] Since this article was prepared, Mr. Adolph Knopf has told the writer that during recent field work he found the Butte granite to cut andesites which should probably be correlated with the Livingston formations. Mr. F. C. Calkins also has found the granite intrusions of the Phillipsburg quadrangle, Mont., to be post-Colorado. Thus recent geologic studies support conclusions and suggestions herein set forth.

SUMMARY

The principal problems discussed in this paper fall under four headings, as follows:

1. An old erosion surface which may prove to be a peneplain, but which because of inadequate study is not so defined here, extends over much of Idaho and into adjoining parts of Montana, Washington, and British Columbia.

2. The surface is assigned to the Eocene because of the relation of Miocene lake beds to it and because of its relation to Eocene deposits.

3. The Eocene surface forms a valuable datum plane in broad areas where time relations between the Algonkian and the Pleistocene are otherwise obscure.

4. It is suggested that the great granitic batholiths of the plateau region either initiated or accompanied the initiation of the cycle of erosion which resulted in the Eocene surface and hence, that they are of late Cretaceous or early Eocene age.